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24 March 1977

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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
BIOMEDICAL SCIENCES
(GIJO 12/77)
EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

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EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

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MECHANISM OF REACTION OF THE HYPOPHYSEO-ADRENAL SYSTEM TO THE STRESS OF EXPOSURE TO AN ALTERNATING MAGNETIC FIELD

Moscow PATOLOGICHESKAYA FIZIOLOGIYA I EKSPERIMENTAL'NAYA TERAPIYA in Russian
No 6, 1976 pp 72-74

[Article by N. A. Udinsev and V. V. Moroz, Department of Biochemistry (headed by Prof N. A. Udintsev) of Tomsk Medical Institute and Inter-VUZ Magnetobiological Laboratory (headed by S. V. Taranov), Tomsk, submitted 7 Jul 75]

[Text] Prolonged exposure to magnetic fields (MF), which are being used more and more in the national economy, may be the cause of impaired function of many organs and tissues [1, 2]. At the same time, MF are beginning to be used for therapeutic purposes [3, 4], often without proper experimental substantiation and analysis of metabolic distinctions related to their effects.

Since we know that formation of adaptive metabolic reactions is largely determined by the state of the hypophyseo-adrenal system (HAS), which is sensitive to MF [5, 12], our objective was to investigate the functional activity of HAS in white rats that were exposed for different periods of time to alternating current magnetic field (ACMF) of 200 H [oersted]. Fields of such force are used in technology and they are referable to stimuli of "moderate force" [10].

Method: Experiments were conducted on 275 white male rats that were placed in the gap of a magnet generating ACMF, with a force of 200 H and frequency of 50 Hz, for different periods of time (from a few seconds to 7 days). The animals were sacrificed immediately after exposure. In order to assess HAS functions, we assayed ACTH in the pituitary gland, activity of biosynthesis of steroids in the adrenals in vitro [6], level of 11-oxycorticosteroids (11-OCS) of blood plasma and adrenal homogenate [8], free 11-OCS [9] and steroid-binding capacity of blood serum proteins [7].

Results and Discussion: It was established (Table 1) that no appreciable change is demonstrable in blood plasma 11-OCS level in response to ACMF when switched on and immediately switched off. Evidently, this is due to the existence of a "latency period" in the physiological reaction of the

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Table 1. Effects of ACMF of varying duration on blood plasma 11-OCS content (μ%; M±m)

	Duration of exposure to field, continuous						
	on and immediately off	15 min	30 min	3 hrs	7 hrs	12 hrs	24 hrs
Control	16,8±3,02	19,9±1.3	18,9±1.93	17,4±1,07	16,2±3,5	15,3±1,4	22,2±1,6
Experiment	17,6±2,14	38,7±3,24***	30,4±7,07*	30,7±3,7*	26,3±2,97*	25,7±3,0*	33,4±3,0*
% of control	+4	+94	+61	+76	+62	+67	+50

	Duration of exposure to field, continuous	intermittent, 6,5 hours daily				
	7 days	1 day	3 days	4 days	5 days	7 days
Control	21,2±2,9	16,2±3,5	19,66±0,75	19,8±2,1	19,7±1,8	19,6±1,02
Experiment	32,8±2,5**	26,3±2,9*	26,06±2,1**	14,3±0,8*	16,5±2,2	17,4±1,6
% of control	+55	+62	+32	−28	−15	−12

* $P<0,05$.
** $P<0,01$.
*** $P<0,001$.

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central nervous system to MF [13], as well as the fact that some time is required for hormone synthesis. In the 15th min of exposure to ACMF, the blood 11-OCS level almost doubled. With longer exposure to ACMF, there was no further increase in steroid content, and it remained high, at about the same stable level throughout the experiment. We had previously shown that the elevation of 11-OCS level is attributable mainly to free steroids, with some increase in transcortin saturation [11].

The results were different when ACMF were used intermittently (6.5 hours daily for a week). While the 11-OCS content of blood was high for the first 3 days, on the 4th day their concentration was below the initial level and was not restored, even on the 7th experimental day.

The results of these experiments warrant the assumption that, in the case of continuous exposure to ACMF, a different, stable level of higher HAS activity is established in the animals, whereas intermittent ACMF, of the same parameters, elicited depletion of its function as early as the 4th day, in spite of the fact that the animals were exposed to MF for almost 75% less time. In order to test this assumption, we investigated pituitary ACTH content and steroidogenetic activity in animals exposed to ACMF for the same time, but the first group was exposed continuously and the second, for 6.5 hours daily, for 4 days.

The results (Table 2) indicate that there was an increase in ACTH in the hypophysis and increased intensity of steroidogenesis in the first group of animals. These indices, along with higher level of free 11-OCS of blood plasma, are indicative of a high level of activity of both the central and peripheral elements of the HAS. In the second group of animals (intermittent exposure to ACMF), we observed a decline of pituitary ACTH and depression of steroidogenesis. Tests with administration of ACTH (1 U/100 Gm weight) revealed elevation of plasma ACTH level to 55.3±3.5 µg% in 30 min (versus 76.6±2.6 µg% in the control).

Thus, the data obtained confirm the hypothesis that the functional level of the HAS declines under the intermittent effect of ACMF, and this is apparently the factor that makes it difficult to adapt to such fields.

When discussing the data obtained, the question arises as to the extent of mediation of ACMF action by the HAS. Experiments were conducted on the effect of ACMF on hypophysectomized animals in order to answer this question. However, we failed to demonstrate changes in level of total 11-OCS, proportion between free and bound forms of hormones in blood.

Thus, the data we obtained warrant the belief that ACMF, with a force of 200 H and frequency of 50 Hz, are a rather potent stressor, the effect of which on the HAS depends on the periodicity of exposure to the field. It was also established that the action of ACMF on the organism is mediated, to a significant extent, via the hypophyseo-adrenal system.

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Table 2. Effect of continuous and intermittent ACMF on pituitary ACTH level and adrenal steroidogenesis (M±m)

	Pituitary ACTH (IU/mg)		Steroidogenesis (μg/100 mg/2 hrs)	
	continuous for 24 hrs	6.5 hrs/day for 4 days	continuous for 24 hrs	6.5 hrs/day for 4 days
Control	18,2±0,70	19,8±0,76	13,35±0,9	15,48±1,5
Experiment	24,0±0,35***	17,1±0,9*	18,71±0,71***	12,5±0,7*
Percent of control	+31	−16	+40	−24

* $P<0,05$.
** $P<0,01$.
*** $P<0,001$.

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EFFECTS OF STATIC AND LOW-FREQUENCY MAGNETIC FIELDS ON BEHAVIORAL AND AUTONOMIC REACTIONS OF A HUMAN OPERATOR

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI in Russian No 6, 1976
pp 1131-1136

[Article by M. A. Medvedev, A. M. Urazayev and Yu. A. Kulakov, Department of Normal Physiology and Department of Propedeutics of Internal Diseases, Tomsk Medical Institute, submitted 9 Jan 76]

[Text] A comparison of the results of investigations involving exposure of the organism as a whole to magnetic fields, using various methods [11, 19, 20, 22-24] revealed that the central nervous system (CNS) is one of the functionally most sensitive and, at the same time, structurally resistant systems. As a result of the penetrating action of static and low-frequency magnetic fields (MF), it can be assumed that the morphofunctional changes in the organism are due both to the direct effect of MF on the morphological substrate and change in regulatory, compensatory functions of the CNS.

To date, the question of correlation between autonomic and behavioral functions of the CNS, with exposure to exogenous, artificial, penetrating "nonsensory" agents had been virtually unstudied. Research dealing with physiology of higher nervous activity and vegetative reactions in MF was pursued primarily with animals [9, 12, 18, 23, 25, 28], which limits appreciably the possibility of interpreting the data on the "human level" [5, 8]. For the same reason, in assessing the role of the functional state of the CNS in stability of processes of vital activity (including behavior) in MF we cannot compare the individual distinctions of sensitivity of various objects to MF.

Among the existing works dealing with behavioral and autonomic functions in man, in MF, we should mention the clinicophysiological studies of autonomic and sensory ["sensitive"] disorders in individuals exposed to MF in industry, which were conducted by A. M. Vyalov et al. [6, 7]. In addition, we consider important the experimental research dealing with time of sensorimotor reactions and autonomic indices, which was conducted by a number of Soviet and foreign authors [1, 2, 13, 15, 16, 26, 27]. The results characterizing the psychophysiological and physiological changes with exposure to MF are submitted in these works with reference to individual indices. There

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is no quantitative evaluation of the relationship ["conjugation"] between reactions, but, at the same time, investigation of the correlates of autonomic and behavioral reactions in the presence of MF would definitely broaden our ideas about the physiological and psychophysiological mechanisms of action of this factor; it also has some practical value, in particular for the purpose of checking the state of a human operator in control and tracking systems.

The objective of this work was to investigate the typology of dynamics of sensorimotor reactions and autonomic back-up thereof in a man performing the duties of an operator with his head exposed to direct and alternating [DC and AC], low-frequency magnetic fields.

Methods

The subjects, consisting of 68 essentially healthy people 19-26 years of age, were seated in a special chair with Gel'mgol'ts rings attached to it (30 cm in diameter, 15 cm high) in front of an operator console [4, 14, 21]. The MF generated by the rings acted only on the head. The magnetic flux was directed from top to bottom. The subjects were given the following preliminary instructions: "When the light signal appears press on the button as quickly as possible." The light signals, formed by a generator, were delivered in accordance with the law of random distribution at 3-10 sec intervals. In addition to the sensorimotor reaction time (RT), we recorded simultaneously physiological indices (PI): period of respiratory cycles (inspiration + expiration)--PR (±0.1 sec), period of cardiac contractions (R--R on the EKG)--PCC (±0.01 sec), skin resistance (in the frequency range of 0-10 Hz, on the left hand--Rk (±10 ohm) and temperature in the axilla--T°k (±0.01°C).

On the first day of the preliminary experiments, we recorded RT and PI for 35 min to evaluate their spontaneous individual variability without MF. On the following day, 12-5 min after the start of the experiment, an even (30 sec) delivery of direct MF, at a maximum field current of $8 \cdot 10^3$ a/meter, was provided. After this, all of the indices were recorded for another 10 min. Analogous experiments with alternating, 50 Hz MF, with maximum field current constituting $8 \cdot 10^3$ a/meter also, were conducted 7-14 days after the experiments with direct current MF. The subjects were not informed of the use of MF.

When processing the results, each experiment was divided into three stages. The first stage was considered as the background and, without consideration of the adjustment period (the first 2-5 min of the experiment), it lasted 10 min. The second and third stages also lasted 10 min each.

A stage by stage comparison of RT dynamics was made according to the criteria of functional state proposed by T. D. Loskutova [10]. We selected as the main criterion the level of functional capabilities (LFC), as an index that is functionally related to stability of motor reactions and functional level of the CNS. At the same time, since there is an exponential relationship

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between LFC and mean value and dispersion (Δ) of RT at any stage of the experiment, this criterion was more graphic as a result of greater mobility (range of fluctuations: +10 to -35% in the course of a single experiment), as compared to other indices.

We evaluated the dynamics of PI according to mean values of percentile relationship of the first stage to the second. The correlates of LFC, PR, PCC, Rk and T°k were also percentages. An electronic digital computer was used to process the results.

Results

It was established that there were significant changes in dynamics of motor reactions and PI from experiment to experiment, in those using MF and without the latter, and that they were not reproduceable on the whole (particularly RT) in the same subject. In essence, we observed faster reaction time and decreased LFC of the CNS at the second stage of the experiment. With exposure to both AC and DC MF, this tendency was more pronounced. In the experiments without MF there were 41 subjects presenting LFC deviations from the background within ±10%, this applied to 30 subjects exposed to DC MF, and 22, to AC MF.

Regardless of whether the CNS was exposed to DC or AC MF, there was predominantly a decline of LFC (<-10%). It was possible to differentiate between MF frequencies according to changes in PI. Thus, in the experiments without MF, a reliable increase ($P<0.05$) of PR at the second stage, as compared to the background, was observed in 18 people and a decrease ($P<0.05$), in 22. The other subjects failed to develop reliable changes in this index, at the given level of significance. With regard to PCC, these changes were as follows: an increase in 20 subjects and decrease in 25. The figures are 13 and 32, respectively for Rk, 30 and 29 for T°k. Under the influence of DC MF, there was a change in distribution of directions of PI changes. An increase in PR, with exposure to MF, was observed in 40 people and a decrease, in 14. There was a reliable increase in PCC in 45 subjects and a decrease in 15; the figures are 39 and 13, respectively, for Rk, 14 and 32 people, for T°k. With exposure to AC MF, the reverse process was observed, i.e., there was an increase in PR in 10 cases, increase in PCC in 12, in Rk in 9 and T°k in 48 cases, while decreases in these indices were as follows: PR in 40 cases, PCC in 46, Rk in 50 and T°k in 6 subjects. The changes in RT and PI with exposure to MF were individual in each subject, and the reaction latency period was often indistinct, due to the complex fluctuation of indices.

The Figure illustrates smoothed curves reflecting deviations of the LFC criterion (%) as function of corresponding PI changes in all of the experiments. Exposure to MF elicited negligible changes in indices of autonomic functions among the subjects who retained the initial reaction time, which was inherent primarily in individuals with high absolute background values of LFC (corresponding to low RT and Δ). In an AC MF, these changes reflect excitation of the autonomic nervous system, and in a DC MF, inhibition. The

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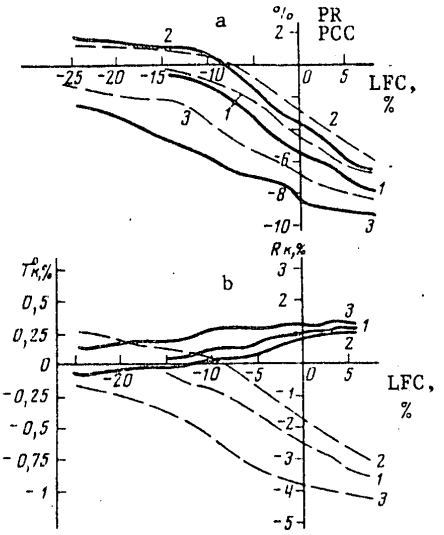
magnitude of deviations of reactions warrant consideration of MF of these parameters as a mild stimulus.



Correlation of dynamics of percentile deviations of LFC and PI; x-axes, percentile deviation of LFC at the second stage, in relation to the first; y-axes, percentile deviation of PR and PCC (in a) and T°k and Rk (in b) at the second stage in relation to the first stage of the experiment

a) for LFC and T°k (solid lines), LFC and PCC (dotted lines)
b) for LFC and T°k (solid lines), LFC and Rk (dotted lines)
1) without MF
2) DC MF, $8 \cdot 10^3 \pm 30$ a/meter
3) AC MF (50 Hz), $8 \cdot 10^3$ a/meter

The Table lists the crosscorrelations ["intercorrelations"] of the indices studied in the experiments without MF, with DC and AC Mf, which were averaged for all subjects. It can be stated that with exposure to MF there is less correlation between changes, not only in RT and PI, but between autonomic reactions. In an AC MF, there is a more significant change in the correlates than in a DC MF.

After removal of MF, we observed primarily recovery of RT (50%) and PI (72%). The recovery process occurred against the background of deterioration of the subjects' efficiency as a result of fatigue, as manifested by somewhat faster respiratory and heart rates, decreased skin resistance and elevation of T°k, as well as decline of LFC.

Discussion

Evaluation of the functional state of the CNS according to the nature of occurrence of sensorimotor reactions enables us to discuss the results of this investigation from the standpoint of the functional system conception of P. K. Anokhin [3] and, at the same time, to single out the distinctions of psychophysiological reactions inherent only in man. The thesis that "the higher the level of the functional system, the more stable it is," is confirmed by the data obtained concerning less deviation of LFC (%) with exposure

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to MF, with high base values of this index. Indeed, the shorter the RT in the background period and the smaller its dispersion, the more grounds we have to predict stable efficiency of the subject at the second and third stages of the experiment. However, in almost all of the subjects, high values of LFC, corresponding to rapid motor reactions, were reached by means of significant changes in the background PI. In subjects with decline of LFC at the second stage of the experiments, the autonomic nervous system was less tense than in subjects with stable reactions. In the same individuals, MF also elicited greater deviations of RT and PI than in subjects with high LFC of the CNS. This correlation between behavioral and autonomic reactions warrants the conclusion that the change in efficiency of subjects exposed to MF is directly related to their set with regard to performing the operator activity, adequacy of attitude toward the investigative procedure and attention. MF elicited virtually no changes in psychophysiological state of subjects who retained a high degree of efficiency throughout the experiment, whereas those who performed the work under less tension were more sensitive to the field.

Intercorrelation between LFC (%) and physiological indices (%)

Indices studied	Experimental conditions	PR	PCC	Rk	T°k
LFC	1	759	797	592	617
	2	721	731	561	593
	3	718	696	555	535
PR	1		911	715	423
	2		885	691	404
	3		872	665	401
PCC	1			793	512
	2			769	506
	3			752	498
Rk	1				898
	2				871
	3				866

Note: 1--without MF; 2--in DC MF ($8 \cdot 10^3 \pm 30$ a/meter); 3-- AC MF (50 Hz) $8 \cdot 10^3$ a/meter; all values for $P<0.01$. Zeroes and decimals have been omitted in the coefficients of correlation.

With reference to the correlation between PI and LFC shown in the Figure, it can be noted that the AC MF elicited intensification of the sympathetic reaction to compensate for the effect of MF and autonomic support of operator activity, while DC MF elicited reduction thereof.

In view of the fact that the MF used are rather weak stimuli, the difference in direction of autonomic reactions can be attributed to the phasic nature of excitation and inhibition with increase in the stimulus [17]. Since the coefficient of absorption of AC MF by biostructures is higher than for DC

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MF, the decreased respiratory and heart rates, temperature, and increased skin resistance warrant interpretation of inhibition of autonomic reactions against the background of established equilibrium as a preventive phenomenon.

The data pertaining to intercorrelation of LFC and PI lead us to conclude that the AC MF is a stronger stimulus than DC MF of the same tension.

Apparently, comparison of reactivity of the organism to MF with the set of the most stable typological, psychophysiological properties, including personality traits determining the individuality of its functional organization, is the most promising approach to evaluation of individual distinctions of changes in the psychophysiological state of the human operator when exposed to MF.

Conclusions

1. Exposure of the CNS to DC and low-frequency AC MF elicits deterioration of psychophysiological state of an individual performing operator functions. The severity of disturbances of reflex reactions and autonomic back-up of performance is directly related to the quality of regulation and adequacy of the individual's attitude to his activity.

2. The penetrating "nonsensory" effect of MF on the set of regulatory and compensatory reactions of the organism causes appearance of a specific component in the adaptation program, which determines the changes in behavioral reactions as a result of initial impairment of autonomic regulation.

3. There are some differences between reactions of the organism to DC and AC (50 Hz) magnetic fields ($8 \cdot 10^3$ a/meter), which are manifested by changes in autonomic functions of the human operator. Thus, AC MF elicits intensification of sympathetic reaction to compensate for the effect of this factor and autonomic back-up of operator activity, while DC MF elicits a reduction.

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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

Moscow TEKHNIKA I NAUKA in Russian No 7 signed to press 16 Jun 76 pp 34-36, and TEKHNIKA I NAUKA in Russian No 9 signed to press 10 Aug 76 pp 30-32

[Article in two parts by correspondent E. Sorkin: "Electromagnetic Fields and Us" from the coverage of the All-Union Symposium on "Mathematical Physical and Biological Problems of the Action of Electromagnetic Fields and Air Ionization" held at Yalta and sponsored by the All-Union Council of Scientific and Technical Societies]

[Text] To develop new methods and means of combating the. . . actions of electrical and magnetic fields and radiations.

From the Basic Development Trends for the USSR National Economy During 1976 - 1980.

We live in a world, an integral part of which are electromagnetic fields (EMP's). For every living thing on the earth, they are just as important as the air, water, light, heat. . . It is now considered demonstrated that changes in the natural EMP's occasioned, for example, by solar flares, have a marked influence on the biosphere. But with the development of technology, man has filled the surrounding environment with artificial EMP's: these are radio waves from television and radio transmitters, and the fields around high voltage electrical transmission lines, as well as radiations from industrial installations. . . Even the everyday fan for a hair dryer in the barber shop also generates an EMP which is significant in comparison with the natural fields. Based on approximate calculations, the average level of the artificial radio background is 10 to 100 times greater than the average level of natural EMP's at the present time. And undoubtedly, all living organisms, including man, in having grown adapted to the natural EMP in the process of evolution cannot but experience a certain influence from the ever increasing radio background. The study of this influence has become an urgent scientific problem. No less important is the further investigation of the action of natural EMP's on the biosphere of the earth. This is why such wide interest within the scientific and engineering community was generated by the All-Union Symposium at Yalta on "Mathematical Physical and Biological Problems of the Action of Electromagnetic Fields and Air Ionization", conducted by the All-Union Council of Scientific and

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Engineering Societies (The Committee on Applied Methods in Mathematics and Computer Engineering, and The Committee on Problems of Protecting the Natural Environment), jointly with the USSR Academy of Sciences, the State Committee of the USSR Council of Ministers for Science and Engineering, the Health Services Ministry of the USSR, the USSR Academy of Medical Sciences, the Central Committee for the Administration of Trade Union Health Resorts. We shall begin with the publication of the notes of our correspondent, E. Sorkin, from this symposium.

Do We Feel a Magnetic Storm?

Not so long ago we found out from the newspapers, radio and television that an extremely strong earthquake had taken place in Guatemala. Tens of thousands dead, millions of people without shelter. . . And immediately one of the reports at the Yalta symposium came to mind. It was stated in it that with the action of various factors (mechanical loading, heating) rocks produce pulsed electromagnetic radiation. This is just the reason, obviously, many animals sense the approach of an earthquake and exhibit unease, abandon the danger-regions. . . If people could sense the change in the electromagnetic fields, if they could run from their homes before the first awful shock! But no, the "master of nature" has come a long way from his wild ancestors, and has lost as useless much of that which our "little brothers" have. And although we are, unfortunately, insensitive to radiations which are the forerunners of earthquakes, this does not at all mean that electromagnetic fields in no way influence us.

Up until now, no one, it appears, has yet attempted to simulate the change in the geophysical fields which accompanies strong earthquakes in order to see how this affects experimental animals. But scientists have modeled magnetic storms. This was reported in a paper by U. Akhmerov of Kazan' University, where an experiment was set up to study the effect on man of an artificial "magnetic storm", close in intensity to the natural level. And what was the result? For all test subjects, a decrease in the frequency of heart contractions by approximately 5 % occurred during the experiment!

Then perhaps, during magnetic storms, it would be better for us to stay in bed, and not subject our health to danger? No, say the scientists, over millions of years of evolution, man has become acclimated to magnetic disturbances, an adaptive mechanism responds for him, and he bears the storm easily, practically unnoticed (for sick people, everything is different, but more on this below). Slightly, ever so slightly, but nonetheless. . . During strong magnetic storms, the number of automobile accidents increases markedly. Industrial traumatism increases. The reason is that the reaction of a person to a signal is delayed. This has been confirmed by experiments, which were discussed in a report by B. Vladimirskiy and A. Volynskiy (The Krymsk Astrophysical Observatory of the USSR Academy of Sciences). With the application of a low frequency (3 Hz) field, reaction time increases by 6 to 10%. And it was even possible to produce a conditioned reflex to the switching on of the field in certain test subjects.

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Earlier, when man did not operate supersonic airliners and rushing automobiles, was not engaged in the extremely precise and high speed machining of metals, when it was not necessary to instantly respond in emergency production situations to the signaling on a control board for entire production lines, then a change in the reaction time by 10 to 15% could be disregarded. Now, it is another matter. The natural magnetic field and its variations have become a factor in production.

The Earth is a Large Magnet

What are the contemporary views of geophysicists on the origin of magnetic storms and the magnetic field of the earth in general? The report of N. Ben'kova of the Instute of Earth Magnetism, The Ionosphere and Radio Wave Propagation of the USSR academy of sciences was devoted to just this question.

The distribution of the geomagnetic field (GMP) over the surface of the earth, and close to it, is similar to the distribution of a field for a homogeneously magnetized sphere with a magnetic moment of $M = 8 \cdot 10^{25}$ electromagnetic units and with an axis running at 11.5° with respect to the geographic axis of the earth. The overall magnitude of the magnetic field, H, varies from 0.6 Oersteds at the poles to 0.3 Oersteds at the equator. The main part of the GMP, the "main" field, exists due to the action of electric currents in the highly conductive outer layer of the earth's core, consisting primarily of fused iron--nickel masses. Electrical currents are induced as a result of convective motions in the liquid part of the core in the primary weak magnetic field. This provides a mechanism for GMP generation similar to the action of a dynamo. Changes in the current system of the earth's core and its individual parts lead to fluctuations in the GMP with a period of from tens to thousands of years.

Theoretical calculations of this natural dynamo indicate that the north and south magnetic poles can switch places from time to time. As a study of the magnetic properties of rocks of different ages shows, changes in the polarity have repeatedly occurred during the geologic history of the earth. The last inversion was approximately 0.8 million years ago, in the middle of the quaternary period. The process of pole alternation lasts for a comparatively short time (in comparison, of course, with the period of stable polarity). But in this time, the GMP loses its regular character, and obviously, decreases significantly.

But this then means that the natural shield around the earth becomes weak, and various radiations can penetrate through it from the outside. . . Is this not an important factor in evolution of all life on our planet?

But before speaking about evolution (this question was touched upon in several reports), it is necessary to discriminate between the other sources of the GMP. The fact is that the geomagnetic field is generated by not only current systems in the earth's core and magnetized rocks (note the Kursk magnetic anomaly), but also by electric currents and wave processes in the upper layers of the atmosphere and space close to the earth.

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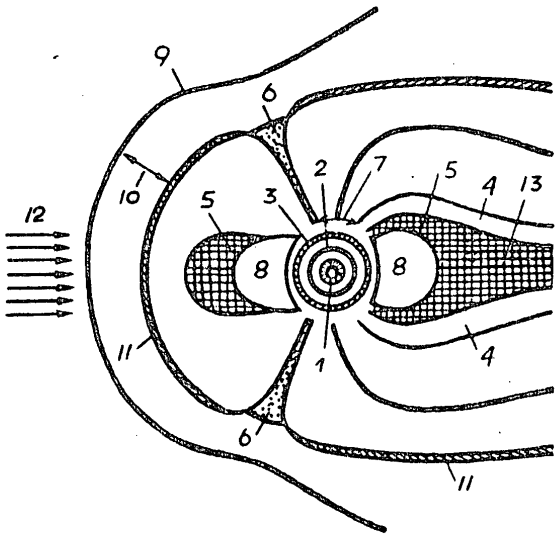
"Despite the fact that the contribution of outside sources to the GMP observed at the surface of the earth is quite small and irregular (no more than a few percent during the most active periods)," it was noted in the report of N. Ben'kova, "The importance of the external field, thanks to its dynamic properties, is probably substantially greater than the significance of the slowly changing internal field for the problem of magnetic-biological relationships."



The Earth's Magnetosphere

Key:
1. The outer part of the core;
2. Magnetically active layer of the earth's core;
3. Ionosphere;
4. Plasma layer;
5. Ring current;
6. Cusp;
7. Polar cap;
8. Plasmosphere;
9. The shock wave front;
10. Transition layer;
11. Boundary of the magnetosphere (magnetopause);
12. Solar wind;
13. Magnetospheric tail;
(The regions of currents are shaded-in).

Studies in recent years, in particular using space vehicles, have shown that the state of the earth's magnetosphere depends on the density and velocity of the solar wind particles, as well as on the interplanetary magnetic field

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carried by the flow of particles from the sun. (Shown in the drawing is a meridianal section through the earth and the magnetosphere, and the configuration of the electrical current systems, the GMP sources, is indicated.) During a disturbance on the sun, when the solar wind increases, the particle flows penetrate the far region of the tail (there where the GMP is quite small) into the magnetosphere, which leads to a sharp increase of the electrical currents in it. This is the reason for a magnetic storm. The solar wind particles can get into the inner magnetosphere and through the cone, which is formed by the lines of force in the regions near the poles: a cusp. In these cases, "diurnal" polar auroras and an increase in the magnetic perturbations are observed.

In a storm period, the density of the particles of the plasma layer increases, and as a consequence of this, the ring current increases, which in turn causes greater reductions in the horizontal component of the GMP. This characterizes the main phase of the magnetic storm.

Magnetic perturbations run a daily course, with a maximum in the evening hours (in the middle latitudes), and a seasonal one, with maxima during the equinoxes. A 27 day repetition rate is observed for GMP perturbations (this is related to the rotation of the sun) as is an eleven year one, which depends on the fluctuations in solar activity.

What Is a "Living" Thing?

What takes place in the human organism during a magnetic storm? Many reports were devoted to this question at the symposium. But in speaking about the action of the GMP on living organisms, it is obviously necessary to say a few words about the concept of "alive" itself.

It was noted in the report of A. Presman (Moscow State University) that "There are no fundamental physical distinctions between living and dead matter, and for this reason it is impossible to propose physical criteria for life." In other words, the physical elements of an organism do not differ in principle from the elements of inanimate nature. In line with this, the author advanced the idea of planetary-space bases for the organization of life, which was formulated in the following fashion: "Life appeared, evolved and now exists on the earth as a single, hierarchically organized cybernetic planetary system, which arose and developed as a regular part of the organization of the universe." Thus, the criterion of life, in the opinion of A. Presman is the organization of the biosphere. Based on contemporary data on the multiplicity of forms and functions of animate nature and its interaction with the ambient earth and space environment, the scientist comes to the conclusion that the biosphere is a cybernetic system in which matter-energy processes are subordinate to information processes. And the universal information carriers from the surrounding cosmos to the biosphere, as well as within it at all levels of organization, are the electromagnetic fields, from ultrahigh to ultralow frequencies.

From this point of view, the opinion of the representatives of the Central Aerological Observatory of the Main Administration of the Hydrometeorological

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Service (N. Pinus, B. Sakhnev, V. Chernysh) has something in common to a certain extent. The compare the "components" of biogeocenosis, the particles, atoms, molecules, cells, organelles, organs, organisms and communities with technical, modern production systems, with unified and standardized assemblies, units and other "assembly units". With such an approach, one can distinguish in animate nature the atomic-molecular "machine tools", "conveyors", etc. The authors consider an indirect confirmation of this "technological aspect" of the structure of biogeocenosis to be the fact that all of the enumerated "product component" units of the ecosystem possess properties of symmetry and assymetry, which are also inherent in all well known technical systems of modern production.

And just what ordains, synchronizes and controls the diverse "organizational and technological" process in the biosphere? The following answer is given: Because of the various forms of electromagnetic actions of solar radiation. Where what is in mind is not the light and thermal energy which arrives through the "optical window" as noted in the report of V. Frolov (The Institute of Evolutionary Animal Morphology and Ecology of the USSR Academy of Sciences), but the radiation coming in through the "radio window", extremely weak electromagnetic fields to which living organisms are especially sensitive. The source of such radiations is not only our sun, but also the constellation Cassiopeia A (a galactic source) and Cygnus A (an extragalactic source), and supernova flares, and pulsars. . .

Life has been in existence on the earth for more than two billion years. Is it now possible to talk with certainty about the factors which play the most important part in evolution? Does something actually change in living organisms from generation to generation under the influence of the electromagnetic field? In the report of S. Pavlovich from the Kalinin Medical Institute, it was reported that an increase in a magnetic field by only 0.5 Oersteds overall had an influence on the mutability of certain types of bacteria. A number of observations by scientists attest to the effect of magnetic fields on the genetic apparatus of a microbe cell. Yu. Achkasova and her colleagues from the Krymsk State Medical Institute have conducted experiments which have shown that a magnetic field with an intensity of 30 gammas exerts an influence on the transmission of the genetic information of microbes.

Consequently, if such insignificant changes in magnetic fields (they are commensurate with the GMP) have an effect on the transmission of the hereditary traits of microbes, then why is it impossible to suppose that in the far past similar changes played a certain role in species formation?

In the Depths of Animate Matter

The most diverse points of view came out at the symposium during a discussion of the mechanisms for the effect of an electromagnetic field on biological systems.

An interesting hypothesis was advanced by V. Danilov (The Joint Institute for Nuclear Research). "The interactions between molecules in animate and inanimate nature are of an electromagnetic character," he stated in his report.

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"For this reason, it is rightful to assert that the processes taking place over a period of time in biological subjects can be found in dynamic equilibrium with the electromagnetic characteristics of the external medium." The following consideration was adduced as an argument. The formation of molecules from atoms takes place, as is well known, by means of the cooperation of a certain part of their electron shells. In this case, a certain number of electrons can prove to be weakly bound to the positively charged nuclei, and form electron charge clouds inside biomolecules. V. Danilov proposes that since the appearance of different biomolecules over a long period of time with the participation of the gravitational field and subject to the action of the electrical and magnetic fields of the earth, which have preferred vector orientations with respect to its surface, then in the evolutionary process, the motion of electrons located in a vertical plane came to predominate in the electron charge clouds (on the average with respect to time). In other words, there are specific contours in biomolecules which play the part of a receiver of electromagnetic energy from the external environment and which are formed by the motion of electrons (in clockwise and counterclockwise directions) via closed trajectories of finite dimensions. Their plane should be oriented in accordance with the cardinal points of the compass, which can result from both the action of the magnetic field of the earth as well as from the presence of a hygroscopic occasioned by the rotation of electrons about the positively charged centers inside the biomolecules, which are located on the earth turning on its own axis.

To check the justification for the hypothesis, scientists conducted a series of experiments. During the action of a slowly changing magnetic field (from 0 to 3 Oersteds over 320 seconds) on lysogenic bacteria, an increase in the phage production by approximately six times was observed. In this case, this effect was detected primarily in the magnetic field with a horizontally directed intensity vector.

Experiments to study the action of a horizontally directed magnetic field varying with time on the chromosome apparatus of human blood lymphocytes have yielded interesting results. It has turned out that the maximum number of disruption of this genetic apparatus (by 17 times in comparison with a control) occurs when the projection of the magnetic field vector is other than zero with respect to the north-south direction. From this, the authors arrive at the conclusion that the position of the electron receivers for the electromagnetic energy of the outside medium, averaged over time, in the biomolecules are located in a vertical plane, positioned in the west-east direction.

With a timewise change in the horizontally directed magnetic field of the earth (and we already know that fluctuations are characteristic of it), a vortex electrical field is induced inside biomolecules in the vertical planes. It acts on the oriented electron charge clouds, increasing their energy or decreasing it, depending on whether the electrons move clockwise or counterclockwise. "This electron cloud, which is in dynamic equilibrium with the electromagnetic characteristics of the outside medium, is also the source by means of which various signals are transmitted inside the structures of biomolecules from the ambient medium," is the conclusion arrived at by V. Danilov.

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"For a known periodicity, the signals can predetermine the running of 'biological clocks' in different subjects in animate nature. . . Given this view, the alternating field of the earth plays the part of a planet-wide metronome."

Ye. Gak and G. Komarov (The All-Union Order of Lenin Academy of Agricultural Sciences imeni V.I. Lenin Agrophysical Scientific Research Institute) emphasized in their report that a lack of knowledge of the nature of the primary physical and chemical processes arising in biological subjects under the influence of the electromagnetic field lessens the value of the great amount of factual material accumulated at the present time by biologists and physicians. Based on both theoretical and experimental work, the authors have arrived at the conclusion that magnetohydrodynamic and electrohydrodynamic effects, which occasion various hydrodynamic phenomena in macrovolumes or in capillary porous media, can arise in living tissues subject to the action of an electromagnetic field.

In accordance with this report is the communication of V. Yevdokimov (Moscow State University) in which he indicates that in biological objects, besides the motion of "bound" charges, the motion of "free" charges also takes place, that of ions in solution with the simultaneous occurrence of biochemical and biophysical processes. The motion of a liquid inside cells is accompanied in practically all cases by the transfer of a rather large number of particles. Thus, the basis for the analysis of irreversible phenomena at the molecular and structural level of the organization of life can be the mechanics of contionuous media, in particular, magnetic hydrodynamics.

The action of an electromagnetic field practically always has an effect on the motion of charged particles. For this reason, the magnetohydrodynamic control of biochemical and biophysical processes is possible.

N. Tikhonova and her colleagues from the Tomsk Medical Institute have proposed another point of view. It is that under the influence of a magnetic field in animate matter, the accumulation of free radicals takes place. Paramagnetic free radicals of unsaturated fatty acids are found in a large amount in cell membranes. In interacting with the magnetic field, they change the permeability conditions of the membranes. Experiments with white mice, which were placed in a magnetic field with an intensity of 200 Oersteds at a frequency of 50 Hz for 6.5 hours, showed that the permeability of cell membranes increases.

(Conclusion to follow)

We now conclude the account of the Yalta symposium organized by the All-Union Council of Scientific and Engineering Societies. (See the seventh issue for the beginning)

Some 134 patients with hypertension were under special observation at the Yurmal health resort. Data on their condition was entered daily in the clinical accounting charts. Kept simultaneously with this was an account of the fluctuations in the geomagnetic field. During the observation

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period, 67 magnetic storms were registered. And it proved to be the case that for 91 of the patients, a deterioration in health set in each time following the magnetic disturbances. Is this accidental?

The Patient in the Geomagnetic Field

G. Yermolayev from the Scientific Research Laboratory in Health Resort Science of the Latvian Council for the Administration of Health Resorts, who conducted these investigations, believes that such a reaction is characteristic of the majority of hypertensive patients.

Yu. Azhitskiy (The Yalta Scientific Research Institute for Physical Medical Treatment Methods and Medical Climatology) discussed clinical observations of 2,188 patients suffering with hypertension, atherosclerosis and chronic pneumonia, as a result of which it was determined that up to 57 percent of the patients were sensitive to helio-geophysical circumstances. Pathological reactions occurred most often when the radio radiation of the sun increased, especially when radio flares were noted against the background of an overall increase in solar activity. In this case, it turned out that the effectiveness of the medical treatment for such patients, in comparison with patients not sensitive to a sharp shift in helio-geophysical factors, was less in any season of the year.

The influence of the intensity of the earth's magnetic field on the development of myocardial infarct was studied at the physiology institute of the USSR Academy of Sciences and Leningrad State University imeni A.A. Zhdanov (report by I. Ganelina, S. Churina and N. Savoyarov). The results are rather unexpected: Over the course of a severe infarct, for hospitalized patients it was not an increased intensity of the earth's magnetic field which influenced them, as was expected, but rather a reduced intensity. It is specifically in these periods that the frequency of myocardial ruptures and contraction deficiency increases.

L. Vinogradova and coauthors (The Institute of General Pathology and Pathological Physiology of the Academy of Medical Sciences of the USSR) studied the influence of a shift in the polarity of sectors of the interplanetary magnetic field (MMP) on patients with vegetative vascular dystonia. The fact is that the MMP, the source for which is the magnetic field of the sun, has a sectoral structure. In certain sectors, the MMP in the plane of the ecliptic is directed predominantly towards the sun (the negative sector), and in others, away from it (the positive sector). At boundaries between sectors on the sun, the active regions are concentrated where flares arise, including proton ones. The intersection by the earth of boundaries between MMP sectors is usually accompanied by a substantial change in the nature of the course of many geophysical phenomena. Comparing the time of the appearance of vegetative vascular paroxysms (crises) of patients with the sectoral structure of the MMP has shown that 71 percent of exacerbations of the illness coincided with a positive MMP orientation, and 29 percent, with a negative one.

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The relationship between changes in the geomagnetic field and the development of infectious diseases is being clearly traced. This was discussed in the report of V. Yagodinskiy (The All-Union Scientific Research Institute for Social Hygiene and Health Services Organization). Influenza serves as a characteristic example: Pandemias of influenza, as a rule, arise during maxima of solar activity and its preminima, when magnetic activity increases. In 1965, based on these data, scientists predicted the appearance of a new strain of influenza virus and the occurrence of its severe epidemic during the period of the solar maximum in 1968. This prognosis was completely confirmed. In fact, a new antigenic variant of the "Hong Kong" virus, which caused the pandemia, began to circulate. The subsequent secondary epidemic waves of flu which researchers predicted were confirmed in precisely the same way.

Is It Necessary to be Apprehensive of Artificial Electromagnetic Fields?

The artifical radio background, as we have already noted, exceeds the average level of natural electromagnetic fields (EMP's) by 10 and at times even 100 times. The medium surrounding us is literally filled with all possible kinds of fields, the source of which is modern technology. But if this is so, then how will we contrive to survive with hundredfold electromagnetic pollution?

Scientists explain this in the following fashion. Millions of years of evolution have made us insensitive to EMP's, the characteristics of which differ from those inherent in natural fields. There are "filters" in the human organism which weed out the "noise", which can be significantly more powerful than the natural EMP's, while the natural signal passes on to the structures of the organism without obstruction. Approximately just as in our hearing apparatus the perception of sound fluctuations takes place only within certain limits. But the capabilities of the organism are not unlimited. For this reason, special standards have been worked out for the maximum permissible EMP levels.

How does the harmful effect of these fields manifest itself? A. Minkh and his coauthors from the Kiev Scientific Research Institute for General and Municipal Hygiene discussed this.

The systematic action of an electromagnetic field on animals, whether at low frequencies (50 Hz at an intensity of 1,000 - 5,000 V/m), medium wave radiations (intensity, 20 - 140 V/m) or short wave ones (7 - 14 MHz at 8 - 50 V/m), ultrashort wave ones (50 MHz at 3 - 10 V/m), or superhigh frequency continuous ones (5 - 50 microwatts/cm^2) or superhigh frequency pulsed ones (10 - 50 microwatts/cm^2), causes marked changes in their organisms. Moreover, the nervous system proves to be the most sensitive to the action of electromagnetic energy. This is expressed in the change in the response to various conditioned stimuli. Observed initially is the excitation of the nervous system, and later, its slowdown. Also detected were changes in the blood, in brain tissues, in the liver, spleen, shifts in heart activity and disruptions of exchange processes.

The studies of V. Popovich and his colleagues from the Scientific Research Institute for General and Municipal Hygiene yielded similar results: Under

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the influence of an EMP at the industrial frequency (50 Hz), the behavioral reaction of animals changes, and their skin and mucous membranes are irritated. The biologically effective threshold intensity for electromagnetic energy for the case of chronic influence is 1,000 V/m.

Low intensity electromagnetic fields in the medium wavelength range also exhibit a biological effect. Thus, conditioned reflexes are formed much more slowly in rats, and they frequently forget that which they have been taught. A study of the state of the health of preschool children (6 - 7 years) and school age children (11 - 14 years), who lived close to medium wave radio stations showed, reported M. Mukharskiy (Kiev Scientific Research Institute for General and Municipal Hygiene), that the prolonged effects on the organism of electromagnetic fields caused functional disturbances in the activity of the nervous and cardiovascular systems, certain exchange processes, and changes in the immuno-biological response of the organism. The biologically effective levels are 140, 35 and 20 V/m.

But artificial magnetic fields, as symposium participants noted, can also have a salubrious effect.

The influence of magnetic fields on patients with chronic, nonspecific polyarthritis and hypertension was studied in particular at the Kuybyshev Medical Institute (V. Fatenkov, S. Aronin, et al.). It turned out that the magnetic field has a favorable effect on both groups of patients. For patients with polyarthritis, the pain in the affected joints decrease after four to six sessions, they begin to move better and the temperature becomes normal. For those with hypertension, the headaches and pain in the heart decrease or disappear altogether, and the arterial pressure drops.

Medical treatment using SHF fields (in the centimeter band) for diseases of the central nervous system, in particular for patients suffering the effects of cranio-cerebral trauma and infectious viral encephalitis, was carried out at the Yalta Scientific Research Institute for Physical Methods in Medical Treatment and Medical Climatology. A rectangular waveguide radiator with dimensions of 30 x 9 cm was employed, which was set up parallel to the back of the patient sitting on a chair. The duration of the radiation at an energy of 0.09 or 0.16 watts/cm^2 was 10 minutes, and the course consisted of 12 to 15 daily treatments. What were the results? For patients suffering the effects of viral encephalitis, the blood filling of the cerebral vessels and a number of other medical indicators improved. For all patients, the bioelectric activity of the brain and the muscles normalized, as did the tonus of the cerebral vessels, certain exchange indicators, blood coagulation, etc.

A study was conducted at the same institute on the influence of comprehensive health resort medical treatment using a SHF electromagnetic field on patients with undulant fever (A. Shatrov). A comparison with a control group, where the EMP was not employed, showed a marked positive effect following sessions of SHF irradiation.

And so, artificial electromagnetic fields are similar to many powerful medicines: in certain situations they can be a "poison", and in others, a healing agent. The important thing is to learn how to use them correctly.

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A Boy or a Girl?

Rather unusual aspects of the action of magnetic fields were touched upon in some reports at the symposium. For example, V. Abros'kin (Voronezh Agricultural Institute) reported on the influence of the earth's magnetic field on the ratio of boys and girls which are born. And here is the hypothesis from which the author proceeds: At the time when the primary sex traits are formed in a human embryo (in the fourth to seventh week of fetal development), the orientation with respect to the magnetic poles of the earth is not an inconsequential matter for it. This can be related to the differing flow velocities in the organism, with its different orientations in the geomagnetic field, of the biological liquids (blood, lymph). They can flow more rapidly to the north than to the south. The difference in the velocity of the flows, the author maintains, should act on the exchange processes influencing the formation of the sex traits or viability of a particular sex (embryonic mortality). But which orientation can we talk about, since the maternal organism is changing it all the time? V. Abros'kin explains that the position of the embryo during the sleep time of the mother should have an effect there (and we do always sleep strictly oriented on the points of the compass, depending on the position of the bed). A comparison of the information on the orientation during the sleep time of the mothers during the first two months of their pregnancy and the sex of the children born gave the following ratio for the 1,452 cases considered: Where the head of the fetus was predominantly positioned towards the north (with a permissible deviation from the meridian of up to 60°) boys were born some four times more frequently, and for the case of the opposite orientation, girls.

A change in the angle of magnetic declination, it states in the report, has a similar influence (it depends on the latitude). The further south the locality is, the closer the equator, the more frequently girls are born. And one more feature was noted: the predominance of boys among newborns going towards the north from the equator (and to the south from the equator, the reverse trend).

In the report of V. Kozlov and his coauthors (Chitinskiy State Medical Institute), the comparison of arterial pressure and the growth of 14 to 15 year old youths was discussed, where they were born in different years of the 11 year solar activity cycle. It turned out that the pressure was higher among those who were born in the year of maximum solar activity. Solar maxima also have an influence on growth: He who, as a rule, was the larger of the youths, was born during these time intervals. The authors arrive at the following conclusion from this: the constitutional features of a baby depend on the level of solar activity in the period of his development in the womb (and the question arises there: But do not artificial electromagnetic fields also play some kind of role in the present day universal acceleration of children?).

V. Chernilevskiy (The Institute for the Evolutionary Morphology and Ecology of Animals of the USSR Academy of Sciences) indicated that the magnetic fields have a more pronounced effect on organisms in their early development than on adults of a species. In this case, the effect can be of a dual sort: positive

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and negative. The first is manifest in the fact that for test animals, aging is retarded! When 70 day old mice were placed in a magnetic field of 4,200 Oersteds with a gradient of 30 Oersteds/cm, then at an age of 400 days (i.e. far into "old age", they appeared significantly younger than the control ones, and their mobility was greater. But this effect was not observed if the experiment was conducted with more "adult" mice.

And, conversely, if the animals were placed in a strongly inhomogeneous magnetic field with a paramagnetic strength on the order of $5 \cdot 10^6$ Oersteds^2/cm, a high mouse mortality was observed. The life expectancy is also negatively influenced by keeping them in a shielded space where the intensity of the geomagnetic field is reduced several times. The signs of aging, flabbiness, low mobility, the appearance of coarse hairs, growing bald, disturbances in the functioning of the liver and kidneys, and swelling, manifest themselves in experimental mice much earlier than in the control mice.

Experiments with domestic flies, discussed by L. Komarov (The Institute for the Evolutionary Morphology and Ecology of Animals), were interesting. Researchers created a field with an intensity of from 223 to 790 Oersteds by means of six horseshoe shaped magnets. They placed Petri dishes in the field with groups of insects, having supplied them with food and drink. And what happened? The average life expectance of the test flies increased by more than 70%. While the maximum expectancy varied from 60 days in the control group up to 78 days in the experimental groups.

The fact that electromagnetic fields act directly on the central nervous system was noted in many reports. In particular, Yu. Kholodov (The Institute for Higher Nervous Activity and Neurophysiology of the USSR Academy of Sciences) indicated that the possibility exists for controlling the activity of the central nervous system using computers by means of varying the ratio of the excitation and retarding processes. In accord with this communication was also the report of N. Sochevanov and V. Matveev (The All-Union Scientific Research Institute for Hydrogeology and Engineering Geology). They believe that practically all people can perceive quite small magnitudes of an external field, in an energy sense, created by "perturbing objects", sites of underground water, continuous and phenocryst sulphide ore bodies, zones of rock fragmentations, as well as by artificial installations: high voltage electrical transmission lines, underground cables, pipelines, cavities in the ground, etc. This perception "shifts over to a psychomotor response": If a person has a framelike indicator in his hands (for example a П or Г-shaped form, made of metal, wood or other material), it begins to turn involuntarily. Thus the unconscious reaction of the nervous system to a change in the intensity of the external field is made manifest. The authors term this phenomenon the "biophysical effect" (BFE) and relate it to the low frequency electromagnetic field of the earth.

The BFE is observed when an operator (a person with an indicator in his hands) moves on foot, in an automobile, an aircraft, etc. Thus, "perturbing objects" are indicated in the path of the operator, and the rotational moment of the

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frame reaches 4,000 - 5,000 g·cm. Will the result be that in this fashion one can prospect for useful minerals? The paper reported on the prospecting for underground water and ores by means of the BFE. Based on the data from checking more than 850 boreholes, more than 80% of the workings discovered the objects sought. In this case, the depth at which the indicator registered ore deposits reached 300 - 400 meters.

The following facts, the authors feel, argue in favor of the magnetic nature of the BFE. When a powerful permanent magnet was brought up to the back of the operator being carried in an automobile, the deflection of the indicator decreased. Additionally, the daily course of variations in BFE intensity is reminiscent of the variations in the vertical component of the geomagnetic field.

To Study, To Control, To Predict. . .

"Questions of the biosphere are quite acute these days, attracting the attention of government, social and state and workers, scientists," it states in the report of the well known Soviet geneticist, Academician N. Dubinin, and his colleagues from the Institute of General Genetics. "Such a tendency is dictated by life itself in connection with the increasing effect of man on nature." The justification for these words was confirmed in the presentations of many symposium participants.

For example, a result of human activity is the modulation of industrial frequencies (high and superhigh) by low ones. This leads to the fact that the fluctuations in the artificial EMP's come close to the natural ones, and this means that people will be sensitive to them. But even fields completely different from the natural ones are not so inoffensive. Arising from this is the problem of working out an all-encompassing system for monitoring industrial EMP sources, whether they are radio transmitters or electrolysis vats in aluminum plants, high voltage electrical transmission lines or radars, television centers or home entertainment equipment.

Another problem also arises in this regard. For you see, as has been explained, healthy people react in different ways to EMP's: the sensitivity of everyone is different. This means it is necessary to have selection by profession for those who work in intensive artificial EMP's.

But selection is not required solely for workers in the region of industrial EMP's. Take, for example, chauffeurs. An increased sensitivity to magnetic storms (shall we say, a slowing of reactions to a signal) can make such a person professionally unfit to a certain extent to drive an automobile. And, perhaps, it is necessary to take another approach? It was indicated in the report of G. Yermolayev that certain medicines help patients suffering hypertension to more easily endure "magnetic" bad weather. The important thing is to forecast it in time. Would not the creation of agents which reduce the sensitivity of drivers to perturbations of the magnetosphere be reasonable in this case?

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And how are we to predict solar disturbances? It is well known that hypertension patients "sense beforehand" a flare on the sun by two days. Instruments on the earth have still noticed nothing and the way these patients feel themselves begins to deteriorate. L. Miroshnichenko (The Institute of Winter Magnetism, The Ionosphere and Radio Wave Propagation) believes that this is related to the reaction of the organism to a change in the potential vector which takes place on the sun prior to the flare. For the organism of healthy people, this, possibly is a signal that it is necessary to "switch in" the adaptive mechanisms which permit one to "not notice" the magnetic storm. But for sick people, this is, alas, a warning of a coming worsening condition.

And is it not time to organize a solar medical service and transmit forecasts by television and radio just as is done for the weather? And such a service is needed for not only sick people and physicians (for the latter, by the way, special courses for advanced training in these subjects are needed). For it is just as important to warn drivers about days when it is necessary to be especially attentive, obviously, as it is to report on tomorrow's icing or fog. And whether forecasts of magnetic disturbances are possible in principle is indicated in the report of L. Vinogradova and her coauthors. Powerful proton flares on the sun have a tendency to arrange themselves closer to the boundaries of the sectors of the interplanetary magnetic field. And since a shift in the polarity of the sectors is forecast sufficiently reliably based on ground geomagnetic data, then it is possible to also forecast magnetic storms.

The time is coming when radio and television announcers will also report to us on a coming earthquake in one region or another. And this is no longer science fiction: L. Vorob'yev and M. Samokhvalov from Tomsk Polytechnical Institute have conducted long term measurements of the intensity of the pulsed EMP of the earth in various seismic regions. And they have detected in the structure of this field the forerunners of earthquakes with an energy of 10^{11} Joules and greater. Prior to earthquakes, a specific perturbation was noted in the field intensity. The earthquake occurred, as a rule, 2 to 70 hours following the maximum of this perturbation.

Biology, medicine, geophysics, biochemistry, astronomy, other sciences and numerous technical disciplines have proved to be "in the same harness" in solving the multifaceted problem of the effect of EMP's on the biosphere and on man. A resolution was adopted at the Yalta symposium to deepen and expand research in this direction. Naturally, the question of coordinating the efforts of scientists and specialists comes up.

As is well known, the reproducability and comparability of the results of experiments in different laboratories is of considerable importance in solving one scientific problem or another. But is it possible to discuss this if researchers work with fields of differing intensities, polarities and frequencies? The devices and instrumentation being used are both nonstandard and unrefined... The necessity of coordinating the scientific research, working out standardized and more refined equipment also results in the extreme complexity of the experiments. B. Vladimirskiy and A. Volynskiy emphasized in their report that

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in the space where the test animal is located, there is in addition to the artificial fields being created, still the natural one, and frequently on top of it also, there is a "foreign" field of industrial origin. These two latter components vary independently of the desire of the experimenter, and this lack of control sometimes leads to the destruction of result reproducability. The utilization of shields is undesirable though, since numerous effects caused by them are as yet poorly studied.

Is it then necessary to talk about how effective the further study of EMP action can prove to be? Besides those aspects which were discussed above, an altogether real possibility is the use of EMP's in agriculture, in particular in animal husbandry to control the ratio of the sexes of the animals which are born, the effect on the organism during the stage of development in the womb, (and this, possibly, will give impetus to the subsequent "acceleration", to the rapid growth of the animal, or, for example, promote greater longevity, which is of no small importance, let us say, for preserving valuable breeding stock).

The natural and artificial fields are an important factor in the environment. They have an influence on us, and we in turn, in modifying the environment, act on the characteristics of all possible radiations penetrating us. It is necessary, as was noted in the report of N. Dubinin and his coauthors, to work out a long term strategy for the optimum interaction of nature and society. In the final analysis, the issue is one of creating a specific model which could form a basis for the advantages of our society.

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CHARACTERISTICS OF MILLIMETER WAVE EFFECTS IN COMBINATION WITH FLUORAFURE ON THE HEMOPOIETIC SYSTEM

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[Article by L. A. Sevast'yanova, S. L. Potapov, N. N. Vasil'yeva, N. I. Krusanova, Ye. I. Kubatkina and R. L. Vilenskaya, Institute of Experimental and Clinical Oncology of the USSR Academy of Medical Sciences]

[Text] The effect of the anticancerous preparation fluorafure in combination with UHF electromagnetic radiation on the bone marrow of mice is investigated. It is shown that UHF radiation weakens the effect of fluorafure. The erythroblastic series, the reticular cells, mature granulocytes and partially the myeloid cells make the greatest contribution to the protective effect. The coefficient of protection is calculated with single and multiple exposure to UHF radiation in combination with fluorafure. It was established during study of some indicators of porphyrin exchange in the erythrocytes, liver and muscles that UHF radiation contributes to intensification of uro-, copro- and protoporphyrins.

It was established recently that the effects of ultrahigh frequency (UHF) millimeter radio waves reduces to a significant degree the damaging effect of X-radiation [5] and a number of chemical preparations [2-4] on the hemopoietic system.

We investigated the rate and nature of recovery of the total number of bone marrow cells and also of different cellular elements of this system (the erythroid, myeloid and lymphoid series and reticular cells) after administration of fluorafure [1] in combination with millimeter waves. It was also established previously [2] that UHF radiation mainly contributes to protection of erythroid growth. It was therefore of interest to study the effect of this factor on porphyrin exchange as a source of heme.

The work was carried out on 250 male mice, hybrid F_1(C_{57}Bl x CBA). The method of exposure in a UHF field was described previously [2, 4, 6]. The animals were exposed to total irradiation for 1 hour with output density of

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2.5 mW/cm^2 and wavelength of 7.1 mm. Fluorafure (4 percent commercial solution) was administered in doses of 100 and 500 mg/kg immediately prior to exposure; moreover, the preparation was administered in a dose of 100 mg/kg once per day for 3 days. The animals were sacrificed after 24 hours and also after 3, 5, 10 and 20 days. The total number of nucleus-containing cells during the indicated periods and after exposure to UHF waves in combination with fluorafure (N_{f+UHF}) and after the effect of fluorafure (N_f) was determined in the bone marrow of the femur; the number of bone marrow cells was also counted in control animals (N_0). The myelogram for 500 cells was counted in bone marrow smears stained after Pappenheim; the number of leucocytes and erythrocytes was counted in the peripheral blood. Based on the data obtained, curves were plotted for each type of cells. The number of mitoses for 1,000 cells of the myeloid and for 1,000 cells of erythroid growth was determined in the bone marrow. In some cases the total number of nucleus-containing cells in the spleen and axillary lymph node was counted.

Histological examination of the internal organs and bone marrow was carried out. The preparations were stained with hematoxylin and eosine.

Biosynthesis of porphyrins (uro-, copro- and proto-) in tissue homogenates of the liver, muscles and blood erythrocytes was studied by using the method of [7], developed for erythrocytes. However, we changed this method with respect to investigation of tissues.

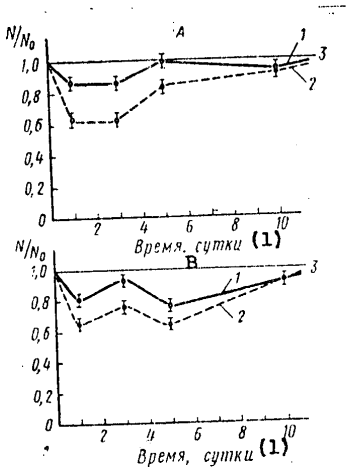

Figure 1. Variation in the Number of Bone Marrow Cells After the Combined Effects of UHF Radiation and Fluorafure: A -- one-time effect; B -- multiple effects: 1 -- UHF and fluorafure; 2 -- fluorafure; 3 -- control

KEY: 1. Time, days

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The number of bone marrow cells (Figure 1, A, curve 1) decreased within 24 hours after one-time exposure to UHF radio waves in combination with fluorafure (100 mg/kg). The value of the ratio N_{f+UHF}/N_0 decreased to 0.9 and remained at this level for 3 days. A rise then began and this value had returned to normal by 5 days. The value of N_f/N_0 was 0.6 within 24 hours after administration of a single dose of fluorafure (Figure 1, A, curve 2) and remained at this level for 3 days. Recovery began only after 10 days.

The value N_{f+UHF}/N_0 changed to 0.80 by 3 days with three-time exposure to UHF radio waves in combination with fluorafure (Figure 1, B, curve 1); the deficit was 0.35 by the 5th day. The number of bone marrow cells had returned to normal by 10 days.

The value of N_f/N_0 (Figure 1, B, curve 2) was 0.65 within 24 hours after three-time administration of fluorafure; it increased to 0.75 by the 3rd day and had again decreased to 0.6 by the 5th day. Total recovery began after 10 days.

The coefficient of bone marrow cell protection with the combined effects of UHF radiation and fluorafure is presented in Table 1. The coefficient of protection (K) was calculated by the formula

$$K = \frac{N_0 - N_\Phi}{N_0 - N_{\Phi+\text{СВЧ}}}.$$

The coefficient of bone marrow cell protection was rather high in the case of one-time and multiple exposure.

Table 1

(1) Вид воздействия	(2) Доза препарата, мг/кг	(3) Коэффициент защиты			
		1-е сутки (4)	3-и сутки (5)	5-е сутки (6)	10-е сутки (7)
Радиоволны СВЧ+фторафур (8) (однократное воздействие)	100	4	4	10	10
Радиоволны СВЧ+фторафур (9) (3-кратное воздействие)	100×3	4	6	2	10

KEY:

1. Type of effect
2. Dosage of preparation, mg/kg
3. Coefficient of protection
4. 1 day
5. 3 days
6. 5 days
7. 10 days
8. UHF radio waves + fluorafure (one-time effect)
9. UHF radio waves + fluorafure (three-time effect)

A gradual decrease in the number of myeloid cells with recovery of their total number by 5 days was observed with one-time effects during study of the rate and nature of recovery of different cellular elements of the bone marrow after administration of fluorafure in combination with UHF radiation.

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Recovery of these cells was completed by the 3rd day after multiple administration of fluorafure. The number of myeloid cells after the combined effects of the preparation and radio waves remained within the control level and increased appreciably after 10 days.

The number of mature granulocytes was reduced identically in both versions of the experiment after one-time effects. However, the recovery process was more rapid with the combined effect, although a second reduction in the number of granulocytes was observed by the 5th day. Discharge of mature cells was noted after 15 days. The number of mature granulocytes decreased within 4 days with multiple administration of fluorafure alone. The deficit of these cells was 72 percent, whereas it was 48 percent with the combined effects.

A significant decrease in the number of erythroblasts was detected within 24 hours after one-time administration of the preparation. The number of these cells then increased and exceeded the initial level by the 5th day (Figure 2, curve 2). The number of erythroblast cells again increased sharply with the combined effects of UHF radiation and fluorafure and decreased after 5 days (Figure 2, curve 1). The number of erythroblasts returned to normal by the 5th day with the multiple effects of fluorafure. A slight decrease in the number of these cells was noted only after 3 days. However, the number of basophilic and polychromatophilic erythrocytes was appreciably lower after multiple administration of fluorafure alone (48-53 percent) than with the combined effects of UHF radiation and fluorafure.

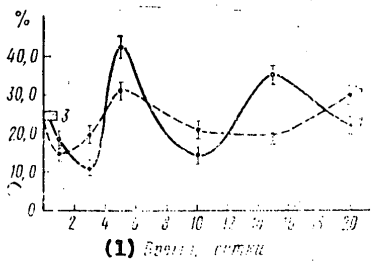

Figure 2. Variation in the Number of Erythroblasts After Combined Effects of UHF and Fluorafure and of Fluorafure Alone. The numerical notations are the same as in Figure 1

KEY: 1. Time, days

Comparison of the nature of erythroblast changes in the bone marrow between the 1st and 5th days after the combined effects of UHF radiation and fluorafure and the use of fluorafure alone permits one to assume that an increase in the number of these cells in the "combined" group was caused by their active profileration. The mitotic index in the group of animals exposed to the combined effects was four times higher in this case than in the group of animals exposed to the effects of fluorafure alone and was two times greater than the control level.

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The number of lymphocytes after administration of fluorafure alone and with the combined effects of UHF radiation and fluorafure varied identically. Their number decreased beginning on the 3rd day and then decreased especially significantly after 5 days. The process of gradual regeneration then began, but the number of lymphocytes did not reach the initial level by the 10th day. A slight reduction of the number of leucocytes was detected in the blood during the first 3 days and then their content reached control values.

The number of reticular cells with the combined effects of fluorafure in a dosage of 100 mg/kg and UHF radiation became three times greater after 3 days than upon exposure to fluorafure alone.

Despite recovery and protection of individual hemopoietic growths, exposure to UHF radio waves essentially does not reduce the toxic effect of fluorafure on the lungs, liver and the large and small intestines. Necroses in the lungs and some atrophy of the mucous membrane of the large and small intestines with necrosis within the crypt are noted in this case. Macrodrop adiposis of the liver is sharply marked and plethora and hemorrhaging in the internal organs are observed.

Intensification of biosynthesis 1.8 times during the first 24 hours and 2.7 times by the 5th day compared to the control was established when investigating porphyrin biosynthesis in the liver of mice that received fluorafure in a dosage of 100 mg/kg. The studied indices essentially did not differ from the norm during the remaining periods. Changes in porphyrin exchange remained the same with the combined effects of UHF radiation and fluorafure as in administration of fluorafure alone. A decrease in the capacity of the hepatic tissues of mice to porphyrin biosynthesis was noted with administration of fluorafure in a dosage of 100 mg/kg and exposure to UHF radiation for 10 days.

Table 2

(1) Объект исследования	(2) Содержание порфиринов, мкг на 1 г белка, в						Содержание порфиринов в эритроцитах, мкг % (8)		
	(3) печени			(4) мышцах					
	(5) уро-	(6) копро-	(7) прото-	(5) уро-	(6) копро-	(7) прото-	(5) уро-	(6) копро-	(7) прото-
Интактные мыши (9)	6,1	29,8	12,0	4,0	11,7	11,5	4,0	170,2	120,0
Мыши, облученные радиоволнами СВЧ (10)	9,0	74,7	37,0	6,0	30,1	7,4	9,0	254,5	169,4

KEY:

1. Object of investigation
2. Porphyrin content, microgram per 1 gram of protein, v
3. Liver
4. Muscles
5. Uro-
6. Copro-
7. Proto-
8. Porphyrin content in erythrocytes, micrograms percent
9. Intact mice
10. Mice exposed to UHF radiation

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Increased synthetic capacity of the tissues and cells compared to the control was determined during study of porphyrin biosynthesis in the erythrocytes, liver and muscles of mice exposed to local UHF radiation on the femur. The data presented in Table 2 show that biosynthesis of all forms of porphyrin (total) in radiated mice compared to that in intact animals was increased 2.5 times in the liver, 1.5 times in the muscles and 1.4 times in the erythrocytes. Biosynthesis of coproporphyrin fractions intensified especially significantly in all the studied objects.

It was established as a result of the investigations that different types of cells participate in implementation of the protective effect after exposure to UHF fields. The erythroblastic series makes the greatest contribution in this case. The number of cells of erythroblastic growth of the bone marrow exceeds the norm by 20 percent by the 5th day. At the same time the number of myeloid cells and mature granulocytes increases significantly.

It is interesting to note the dynamics of the number of reticular cells. The sharp increase of their number after 3 days with the combined effects is apparently the reserve which provides intensive proliferation of myeloid elements during recovery of the hemopoietic function. These same groups of cells also play a leading role in the process of bone marrow recovery with multiple exposure.

Only the lymphocytes essentially remain unprotected. Their number is even somewhat less under the combined effects of fluorafure and UHF fields than with the effects of fluorafure alone.

The total number of myeloid cells and also the coefficient of protection remain high as a result of a significant increase in the number of myeloid cells of specific groups upon exposure to UHF radiation in combination with fluorafure. The coefficient of protection was equal to 4 and in some cases to 6 for fluorafure.

Investigation of some characteristics of porphyrin exchange showed that biosynthesis of uro-, copor- and protoporphyrins in the liver, muscles and erythrocytes increases with the effects of UHF radiation alone.

Thus, the effect of ultrahigh frequency millimeter waves may contribute to an increase of the functions of some biological systems [6] and may accelerate the recovery process in the hemopoietic tissue.

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USE OF MAGNETOPHORES IN MEDICINE, INDUSTRY

Moscow TEKHNIKA I NAUKA in Russian No 12, 1976 pp 7-10

[Article by A. Mandrugin (Leningrad): "The Magnetophore: What Is It?"]

[Text] Magnetophore...You won't find this term yet in any encyclopedia or technical dictionary. But you can hear it frequently in the Leningrad Sever Textile-Haberdashery Production Association. The word is now becoming popular outside the association as well. Letters are coming to Leningrad from Moscow and Kiev, from the Far East and the Caucasus. They all have one request: send us magnetophores.

Let us briefly list several spheres of possible use of magnetophores. In agriculture--for pre-planting seed treatment, for making granules used in hydroponics, for magnetic treatment of water intended for irrigation, for protecting plants and grain stocks, and for magnetotherapy of farm animals and livestock. In microbiology--for preventing microbiological corrosion of industrial materials and products, for intensifying processes of microbiological processing of low-grade ore and industrial wastes, for sewage treatment, for increasing the production of protein, alcohol, vitamins and enzymes. In hydrobiology--for suppressing the life activity of organisms growing on the underside of boats and structures, for intensifying processes of the artificial propagation of fish. In medicine and labor hygiene--for the development of magnetophore clothing to protect against constant magnetic fields and high-energy electromagnetic fields, for eliminating the harmful effects of the lack of magnetic fields in a screened facility...An impressive list, is it not?

What are magnetophores? In essence, they are magnetic recording media similar to the tapes and cards used for the magnetic recording of images--magnetographs. They are made from a mechanical mixture of organic and mineral binders (resin, rubber, gypsum, cement, slag, water glass, and so on) and powder-form hard-magnetic fillers (barium ferrite and megnetic alloys), giving the products the necessary profile and size. Such mixtures are also used to make various coatings in the form of pastes, putties, emulsions, suspensions, and so on.

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Shaped magnetophores and magnetophore coatings get their special properties from the special conditions of magnetization. By means of a shaped inductor-megnetograph, magnetograms of fields of the required parameters are recorded on their surface: parameters of form, intensity, gradient, energy, and magnetic capacity.

One of the most important spheres of use of magnetophores is medicine: the fields created by magnetophores in the space around them are capable of affecting the properties of the liquid media and the vital functions of biological specimens. According to Moscow medical specialists, magnetophore bandages speed up the healing of post-operative wounds and shorten the healing time a suppurative processes (abscesses, phlegmons, and so on). And tests conducted in Kiev's City Hospital No 13 show that magnetophore bandages in 85 percent of the cases heal cases of radiculitis, acute thromophlebitis, arthritis, polyarthritis, and they speed up the knitting of broken bones. In the therapy department of Leningrad's Consolidated Hospital No 9 it was found that magnetophores help to clear up the disease syndrome in cases of ischemic heart disease (stenocardia). And urologists in the same hospital used magnetophore suppositories to heal prostate disorders without having to operate.

In short, the number of diseases that give way before the magnetophores is large. They include hypertension and various gynecological disorders, diseases of the ear, throat, and nose, also burns...According to oncologists of the Leningrad Oncology Institute imeni Petrov, magnetophore bandages even eliminate the pain syndrome in cancer of the lungs, and experiments conducted with mice have shown that under the effect of magnetophores the growth of malignant tumors ceases in 70 percent of the animals experimented on. The list of diseases susceptible to treatment is growing as research expands. This became especially noticeable after a commission on instruments and equipment used in physiotherapy, under the USSR Ministry of Health Administration of the Adoption of New Treatments and Medical Equipment, recommended that magnetophores be turned over to several medical institutions for clinical testing.

Although it is perfectly to all that magnetophores have a great future, it is difficult to say in what other areas of human activity they will prove beneficial, since as yet there is no theory to explain the effect of magnetic fields on biological objects. There are a number of hypotheses (See TEKHNIKA I NAUKA, No 7, 1976, and No 9, "Electromagnetic Fields and Us"). One hypothesis comes from A. Fefer, the inventor of magnetophores (Inventors Certificate 445438). In brief, it boils down to this. Artificial and natural magnetic fields affect the life functions of biological objects indirectly. They act on the structures of the cellular substrates, on the biochemical luminescence of the cells, and consequently they are capable of affecting intracellular metabolic processes. By changing the intensity, gradient, and form of the magnetic field it is possible to exert a directive effect on the vital functions of biological specimens of animal or plant origin. How accurate this proposal is, the future will show. Meanwhile, the experimental use of magnetophores unequivocally indicates that they activate the life activity of organisms and enhance their power to combat ailments.

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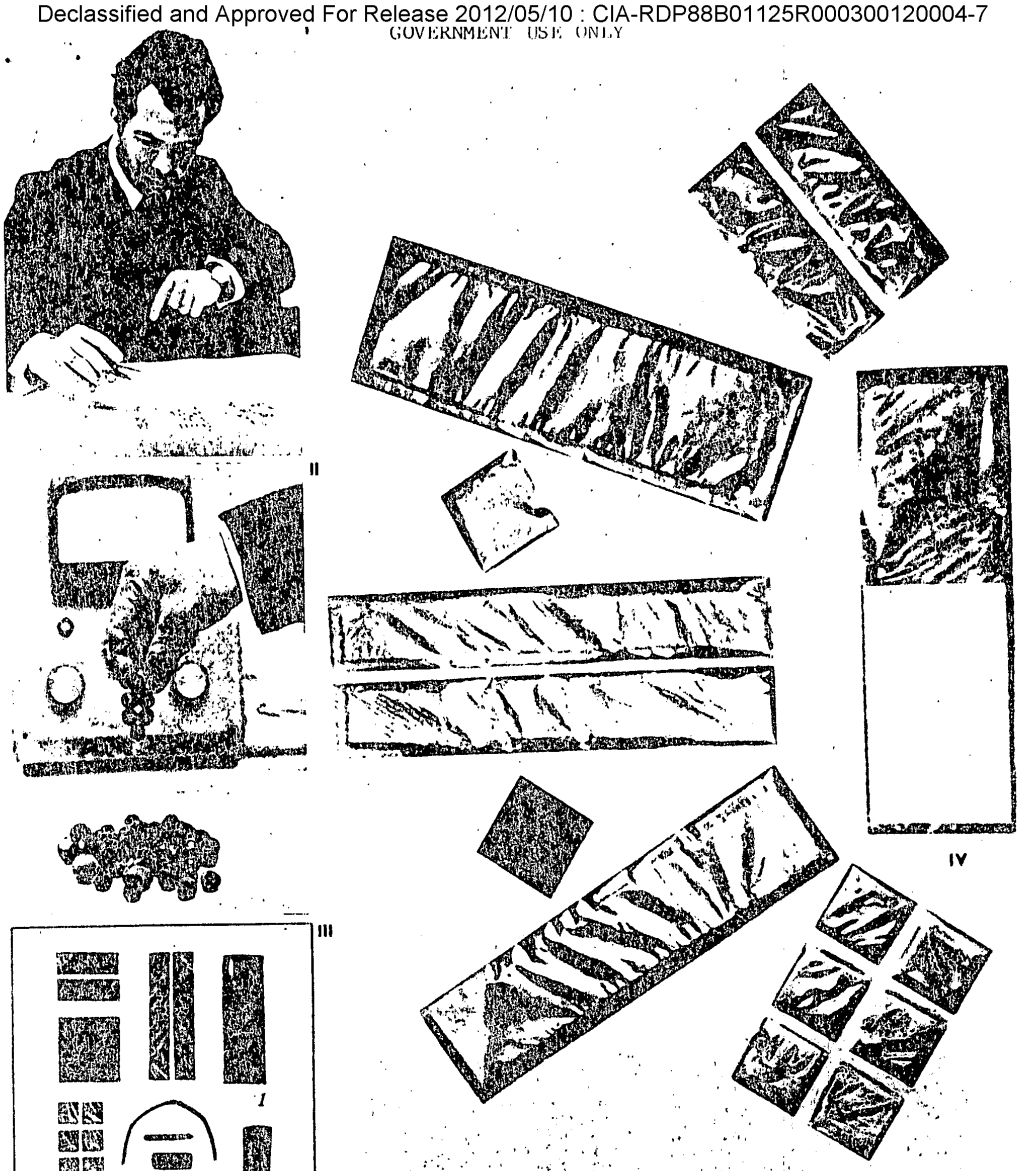

I. Magnetophore laboratory director Yu. Zatepyakin
II. Spheres made from a mixture of binding materials and hard-magnetic fillers, adhere together very well
III. Samples of magnetophores based on various binders: 1 - rubber; 2 - gypsum; 3 - cement
IV. Magnetophore bandages
V. Manual treatment device
VI. Table-top magnetophore device for treating various disorders.
VII. Knitting of broken bones is speeded up considerably under the effect of magnetophores.

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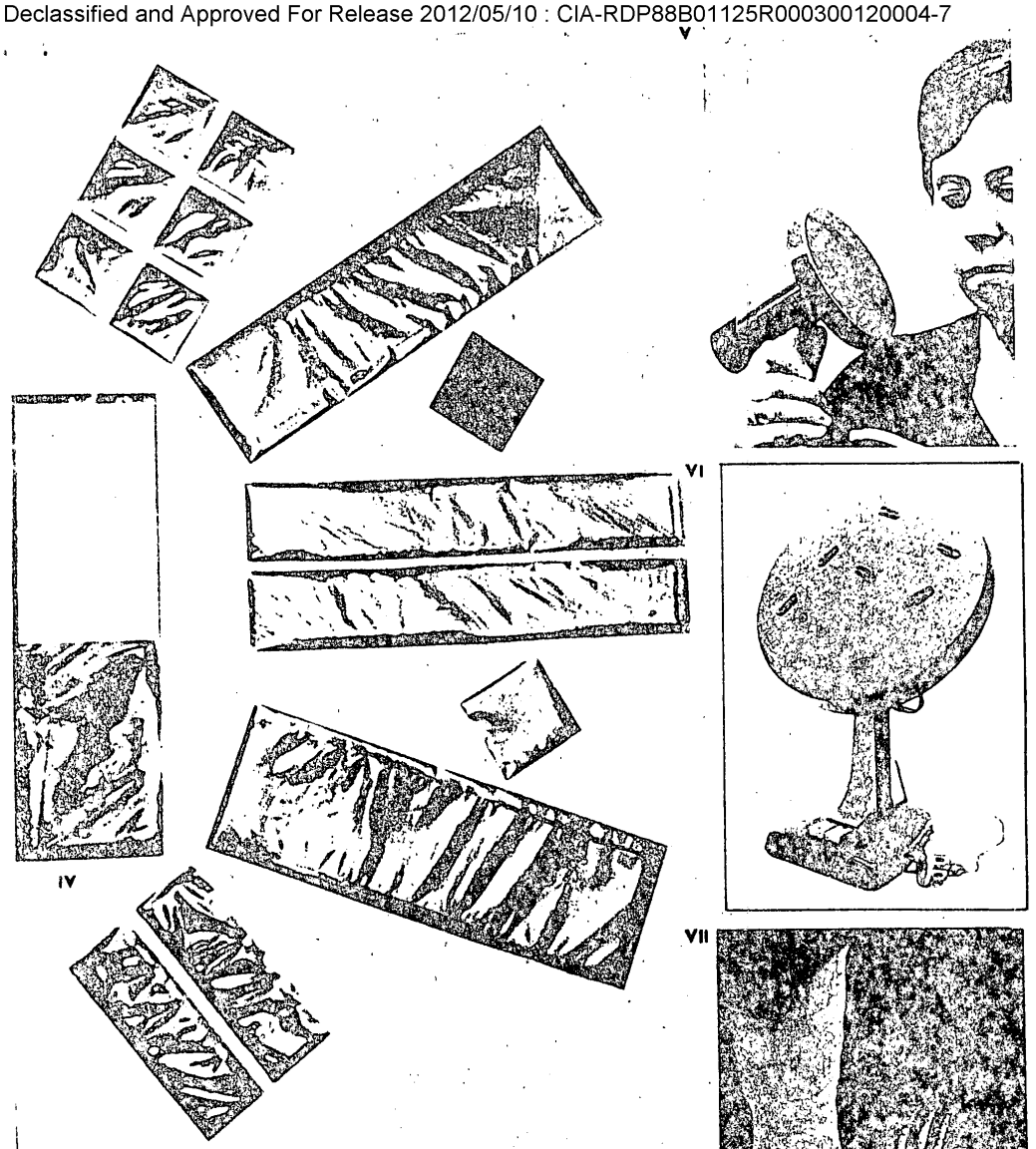

I. Magnetophore laboratory director Yu. Zatepyakin; II. Spheres made from a mixture of binding materials and hard-magnetic fillers, adhere together very well; III. Samples of magnetophores based on various binders: 1--rubber; 2--gypsum; 3--cement; IV. Magnetophore bandages; V. Manual treatment device; VI. Table-top magnetophore device for treating various disorders; VII. Knitting of broken bones is speeded up considerably under the effect of magnetophores.

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Various instruments which affect biological and other objects by means of a magnetic field have already been in use--and for more than one year!--in medicine and in industry. How do magnetophores differ from them? First of all, by their simplicity, convenience of use, and low cost. Almost every one of us has had occasion to visit physiotherapy offices and see how complex their equipment is. Furthermore, having undergone treatment, the patient has to rest in the facility before going outside. But surely this amount of lost time is inefficient for a person undergoing treatment without having to fill out a doctor's certificate. Magnetophore bandages, on the other hand, do not require this "treatment procedure." They can be put on or taken off at home, or in some cases at the work place. Incidentally, the cost of magnetophores comes to a few rubles.

I should like to illustrate all the above with an actual example of the use of magnetophores in industry. In the Leningrad Thread-Spinning Combine imeni Kirov and the Ivanovo Worsted Wool Combine, in particular, megneto-phores have been used to intensify dyeing processes. It is found that the quality of the dyeing is much better, and the amount of dyes used decreases by 10 to 20 percent. Consider another example. It has been proven that magnetized water has a beneficial effect on the yield of farm crops. But these undertakings used to require rather complicated installations and electrical connections. And such facilities until now were very costly. Magnetophores greatly simplify the process of magnetizing water under field conditions. They do not need to be "fed" with electricity, as electromagnets do, and they retain their magnetism for seven years at temperatures ranging from -20 degrees to +40 degrees C.

And so, magnetophores have demonstrated their right to exist: interest in them and demand for them are growing day by day. But the demand is not being satisfactorily met at all. Yet it is not the fault of the enter-prises. The Leningrad Sever Association is engaged in the production of megnetophores--an enterprise of a special kind. At one time it produced textiles for industry, but several years ago it was assigned the job of producing items for medical needs, and rather complicated and critical ones at that. They included sutural material (threads of varying thickness to stitch wounds), artificial ligaments, tendons, blood vessels, heart valves, and many other items used in surgery.

The enterprise put together a good collective, capable of solving not only production tasks but also scientific ones. And when A. Fefer came to Sever with his proposal, he met with understanding and interest on the part of the collective. A special magnetophore laboratory was set up. It was put in the charge of the resourceful and energetic engineer Yu. Zatepyakin. The laboratory is involved in scientific research experiments, and manufacture of magnetophores. Initially, when the laboratory was looking for ways to use magnetophores, its output was sufficient. But now times have changed. Many medical institutions are turning from the testing to the extensive adoption of the innovation in medical practice, and they require magnetophores by the dozens and hundreds. The laboratory is no longer able to meet the demand--it only employs 10 persons, and operations are housed in two small rooms...

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Increasing the staff of the laboratory and expanding the production area is the first problem which the RSFSR Ministry of Textile Industry must solve. Obviously, this should involve the creation fof a special shop. But the chain stretches further. The manufacture of most of the megnetophores requires semi-finished products--special runner plates. These are manufactured by the Leningrad Krasnyy Treugol'nik Plant and the the Tula Industrial Rubber Products Plant. But these plants supply them to the laboratory on the basis of a "gentleman's agreement, thanks to good relations with the Sever management. When it was just a matter of a few dozen kilograms of rubber there was no problem. But to take care of today's demand, tons are needed. The enterprises cannot supply this amount of rubber "just like that." Such deliveries must be formulated in a plan, the necessary material stocks have to be allocated.

But, very likely, special importance attaches to the problem of including a theme related to megnetophores in the state plan of scientific-research work. Until now all these undertakings have taken place on the basis of personal initiative. The question arises as to the idea of creating an inter-sector commission able to prepare the appropriate recommendations on including the invention in the state plan for the adoption of new technology. In this connection let us recall that the "Basic Directions of Development of the National Economy USSR for 1976-1980" specify the necessity of "developing and widely adopting radically new equipment, new structural magnetic, semiconductor, superconducting, and other materials..." In all probability, the activists of those sectors in which the use of magneto-phores is especially promising should also focus attention on the Leningrad innovation, and endeavor to have it adopted in production.

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HUMAN CARDIOVASCULAR SYSTEM UNDER THE INFLUENCE OF A SUPERHIGH-FREQUENCY ELECTROMAGNETIC FIELD

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 1 1977 pp 18-21

[Article by V. P. Medvedev, Institute for the Advanced Training of Physicians imeni S. M. Kirov]

[Text] Extensive application of superhigh-frequency electromagnetic fields (SHF fields, microwaves) in science, engineering, industry, and medicine has produced a situation in which continually larger numbers of people are subjected to this physical factor with every year. Various aspects of the biological action of an SHF field have been thoroughly examined in the reviews and monographs published in recent years (5,21,30,32). The action of microwaves upon the human cardiovascular system has been subjected to less study. This review categorizes the basic data published on this issue.

Authors of earlier works (1) were unable to find deviations in the state of the cardiovascular system of radar station operators. Later they were often found to exhibit systolic murmur and dulling of the first heart sound (15; Ye. V. Gembitskiy, 1962). Changes experienced by workers tuning and adjusting SHF generators are more pronounced (13,20,33). Signs of myocardial dystrophy were often discovered in such workers. Subsequently almost all authors described dulling of the first heart sound and a soft systolic murmur above the apex of the heart in persons working with SHF field generators over a long period of time (6,8,10,32).

Thus physical changes of the heart are not revealed or they occur rarely in young radar station operators with a short time of service in the presence of SHF fields. Dulling of the heart sounds, shifting of the heart boundaries, and systolic murmur could develop in workers having longer contact with SHF fields of greater intensity.

Data on the frequency of ECG changes in the presence of chronic exposure to an SHF field are contradictory. While N. V. Uspenskaya (33) discovered deviations from normal in 71 out of 75 ECG (95 percent), Ye. V. Gembitskiy (1966) discovered such deviations in only 19 out of 120 ECG (16 percent).

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A. A. Kevork'yan had described change in pulse rate in response to a centimeter-band SHF field as long ago as in 1948. The frequency of occurrence of bradycardia increases as the intensity and duration of exposure grow (28). Exposure to a centimeter-band SHF field leads most often to bradycardia (20). Slowing of the pulse is more pronounced during the time of work with SHF generators (22). A number of authors have also noted tachycardia (8,15,21). It was discovered in 36 percent of patients with an autonomic vascular dysfunction syndrome elicited by exposure to an SHF field (4). Change in heart beat frequency reflects disturbance of the tone of the parasympathetic and sympathetic divisions of the nervous system.

A. A. Orlova, N. M. Konchalovskaya et al. often discovered sinus arrhythmia in the presence of exposure to an SHF field. Atrial and ventricular extrasystole has been described (4,32; Ye. V. Gembitskiy, 1966). Its frequency varies from 2 percent (20) to 14.5 percent (N. V. Uspenskaya, 1963). Extrasystole is more often encountered together with manifestations of SHF field injury. Intra-atrial and intraventricular conduction is slower in workers operating SHF field sources for a long period of time (18,20). Ye. V. Gembitskiy (1966) and M. P. Troyanskiy have revealed similar changes in radar station specialists. Atrioventricular blocks were encountered significantly more rarely (32). The height of R and T spikes in the ECG recorded from workers with standard points of contact exhibit a decline (20,35), or only the T spike declines, especially with left thoracic points of contact (8,13).

The etiology of so-called muscular changes requires special evaluation each time. In a number of cases these changes reflect earlier development of atherosclerosis of coronary arteries. The fact that a $T_{V_1}>T_{V_6}$ electrocardiographic syndrome was revealed in 30 percent of the radar station regulators examined (P. N. Fofanov, 1968) as well as clinical observations by K. V. Glotova and M. N. Sadchikova, in which chronic coronary insufficiency was discovered in 8.6 percent of patients with radio-wave disease, argue in favor of this suggestion.

N. A. D'yachenko revealed deviations from normal in chronocardiograms for 23 out of 62 radar station specialists, such deviations occurring in only 2 out of 22 cases in control. The following were encountered most often: Lengthening of the period of tension, reduction of the length of mechanical systole and the intrasystolic index, and decline in the mechanical coefficient. These changes correspond to a phasal hypodynamic syndrome. V. I. Muratov and A. P. Turayeva discovered similar disturbances in 14 out of 25 radar station specialists. Agreement in data obtained from examination of groups of workers characterized by similar age and nature of work is indicative.

The systolic and minute blood volumes of SHF generator tuners and regulators were often high (16; F. I. Komarov et al.). Similar data were obtained by Ye. V. Gembitskiy (1966) from radio operators and patients with neurocirculatory dystonia caused by exposure to an SHF field.

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Systolic volume is low in workers with a long time of service exposed to an SHF field; in combination with a reduced volumetric ejection rate and bradycardia, this leads to a distinct drop in minute volume (34; P. N. Fofanov, 1968). Yu. D. Pevzner described negative correlation between the size of the minute volume and time of service with SHF generators. Measurements of arterial pressure taken from different groups of workers involved with SHF field sources are presented in the table below, from which we can see a comparable frequency of hypotonia in workers involved in different studies (22.6-28 percent). Hypotonia is encountered especially often in women.

Frequency of Deviations From Normal in Arterial Pressure in the Presence of Chronic SHF Field Exposure.

Авторы (1)	Характеристика обследованных (2)	Число обследованных (3)	(4) Частота, % гипотоники (5)	гипертоники (6)
12	Инженерно-технические работники (7)	87	38	
20	Рабочие (8)	525	28	
N. V. Uspenskaya (1961)	Работницы (9)	84	30	
23	»	92	61	
35	Рабочие (8)	172	25,5	5,8
F. I. Komarov et al.	»	53	22,6	
11	Операторы РЛС (10)	66	6,0	7,8
13	Рабочие (8)	184	26	
8	Больные радиоволновой болезнью (11)	100	15	17
15	Рабочие (8)	85	19	15
Ye. V. Gembitskiy (1966)	Радиометристы (12)	210	14	
P. N. Fofanov (1968)	Рабочие (8)	30	27	
9	Операторы РЛС (10)	62	22	29
4	Больные радиоволновой болезнью (11)	105	47	24
28	Рабочие (8)	215	7	14—23
19	Операторы РЛС (10)	25	0	28
17	Инженерно-технические работники (7)	154	0	11

Key:

1. Authors
2. Examinee job description
3. Number of examinees
4. Frequency, percent
5. Hypotonia
6. Hypertonia
7. Engineers, technicians
8. Workers (male)
9. Workers (female)
10. Radar station operators
11. Patients with radio-wave disease
12. Radio operators

In addition to a decline in arterial pressure, a rise has also been described in the last 10-12 years (see table). Apparently this stems from an increase in time of service with SHF field sources, and it has been revealed not only in common laborers but also radar station operators.

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And so, change in arterial pressure of persons subjected to SHF fields for a long period of time can have a hyptotensive and a hypertensive orientation depending on time of service, the working conditions, and individual features of the body. Hypotonia is typical of the initial stage of radio-wave disease, while hypertonia may arise in its second stage, during development of an autonomic asthenic syndrome accompanied by spasm of arterioles (7).

Both a rise in vascular tone (17,13) and its decline (F. I. Komarov et al.) have been noted in response to an SHF field. Probably the orientation of changes depends on individual reactivity. Vascular tone can be evaluated objectively by measuring the rate of spread of a pulse wave through muscular (R_m) and elastic (R_e) arteries. Most authors indicate a rise in R_m (8,9,18; Ye. V. Gembitskiy, 1966). Later, in addition to a rise in R_m a rise in R_e was described--in workers having a time of service over 5 years in the presence of an SHF field (15), and in persons doing mental work (17).

Peripheral resistance can be both higher (18,32; P. N. Fofanov, 1968) and lower (9; Ye. V. Gembitskiy, 1966) in the presence of chronic exposure to an SHF field.

It would be natural to expect that disturbance in vascular tone and hemodynamics, as well as humoral changes developing in the presence of chronic SHF field exposure may have an effect on the way the individual feels. Persons working for a long time in the presence of SHF fields note the following complaints on the part of the cardiovascular system: Heart throbbing, shortness of breath, and unpleasant cardiac sensations and pains of different natures. The frequency of complaints grows with increasing time of service (3,10,20) and with higher SHF field intensity (10,28).

These complaints reflect chiefly the development of neurocirculatory dystonia and myocardial dystrophy. However, earlier development of coronary insufficieny is also possible, having been discovered in nine out of 105 relatively young persons working for a long time with SHF generators (4). Indications of earlier development of atherosclerosis in such persons have also appeared (17,29). Affliction of the diencephalic region in response to an SHF field, leading to disturbance in regulation of cardiovascular tone and lipid metabolism, provides the grounds for assuming accelerated development of atherosclerosis to be a fully realistic possibility.

A tendency toward vasospasm, which could be accompanied by development of hypertonia, has been described in pronounced stages of radio-wave disease (7,13).

Cases of myocardial dystrophy, coronary insufficiency, and hypertonic illness apparently increase in frequency as time of service in the presence of SHF fields increases (4,8,17).

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It is important to emphasize that the nature and degree of affliction of internal organs by exposure to an SHF field go a long way in defining the outcome of such afflictions (25).

Notions on the stability and reversibility of cardiovascular afflictions arising in response to SHF fields are changing. While it had been considered formerly that all disturbances disappear soon after work with SHF field sources is stopped (6,26), data of the last few years have indicated that these disturbances are stable and weakly reversible (2,17,29,31).

SHF fields are a new ecological factor. Further research on their influence upon the human body and, in particular, upon the cardiovascular system can help us to develop reliable ways to recognize and prevent radio-wave disease.

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EFFECTS OF ULTRAHIGH FREQUENCY ELECTROMAGNETIC FIELDS ON CONTRACTILE ACTIVITY OF THE HEART (EXPERIMENTAL STUDY)

Alma-Ata ZDRAVOOKHRANENIYE KAZAKHSTANA in Russian No 1, 1977 pp 71-72

[Article by Zh. N. Sartayev, Chair of Normal Physiology (headed by Prof A. A. Samokhina), Karaganda Medical Institute (Docent A. P. Filin, head)]

[Text] In works dealing with investigation of the effects of ultrahigh frequency electromagnetic fields on the cardiovascular system there is absolutely no information on phasic changes in myocardial function characterizing contractility of the myocardium.

The objectives of the present work included investigation of the effects of UHF [ultrahigh frequency] electromagnetic fields on contractility of the myocardium, with exposure of the region of the head. This study was conducted on dogs submitted to chronic experiments. The region of their head was exposed for 10-12 days, daily, using a UHF-4 unit, with 20-min exposure and 20 V force. Analysis of myocardial contractile activity was made by the method of Blumberg-Haldeck as modified by Karpman, on the basis of polycardiograms. We conducted 72 experiments in all, on 6 dogs, and analyzed 495 polycardiographic curves.

The studies established that exposure of the animals' head to UHF electromagnetic fields was associated with decreased contractile function of the myocardium and the hypodynamic syndrome. This was indicated by extension of the phase of isometric contraction, most often combined with shortening of expulsion phase.

The immediate cause of poorer contractile function of the left ventricle was a decrease in systolic volume of the heart and in delivery of venous blood to the heart as a result of manifestation of a vagotonic effect on the heart.

Our data may be taken into consideration in physiotherapeutic practice, when ordering UHF electromagnetic field therapy for patients with a marked vagotonic effect which, with exposure of the head region to UHF electromagnetic fields, even in therapeutic doses, is also indicative of the need to protect individuals working with high-power generators that emit high-intensity electromagnetic fields in the ultrahigh frequency range.

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EFFECT OF EXPOSURE OF THE THORAX TO SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS ON CONTRACTILE FUNCTION OF THE HEART (EXPERIMENTAL STUDY)

Alma-Ata ZDRAVOOKHRANENIYE KAZAKHSTANA in Russian No 1, 1977 p 73

[Article by Z. S. Gurevich, Chair of Normal Physiology (headed by Prof A. A. Samokhina), Karaganda Medical Institute (Docent A. P. Filin, head)]

[Text] We were prompted to conduct this experimental investigation by the small number of observations pertaining to changes in such an important function of the heart as contraction, as related to extensive exposure of the body to electromagnetic waves. We recorded polycardiograms on a four-channel loop oscillograph in the form of a photographic recording and determined the duration of systolic phases of the left ventricle according to the synchronous tracing of the electrocardiogram, phonocardiogram and sphygmogram. Analysis of contractile activity of the myocardium was made by the method of Blumberger-Haldack as modified by Karpman.

We studied the following time intervals: heart cycle, phase of asynchronous contraction, phase of isometric contraction, postsphygmic and sphygmic periods, mechanical systole, total systole, electrical systole, protodiastolic interval and ventricular diastole. In addition, we investigated relative parameters characterizing cardiodynamics: intrasystolic index (ISI) and Blumberger's coefficient.

We recorded the polycardiogram for 5-10 min during exposure to electromagnetic fields and for 5, 15, 25 and 40 min after exposure to SHF [superhigh frequency] electromagnetic fields from a Luch-2 source. The right chest was exposed to a cylindrical emitter, 11.5 cm in diameter. Microwave exposure time constituted 10 min at 10-15 watts. The procedures were administered daily and a course consisted of 10 sessions. In all, we conducted 60 experiments on 6 dogs and analyzed 420 polycardiograms.

These studies revealed that exposure of the right thorax to SHF electromagnetic fields for 10 days resulted in extension of the heart cycle and diastolic time, elevation of ISI, extension of ejection period due to a shortened period of contraction. All these changes in phasic structure are indicative of improved myocardial contractility against the background of increased filling of ventricles and stroke volume. Evidently, exposure of the chest

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to electromagnetic waves in the SHF range, in therapeutic doses, leads to reflex intensificationof biochemical enzymatic processes in the myocardium.

The results of our investigations are of both theoretical and practical value. Thus, analysis of the phase structure of the left ventricular systole, along with the results of other clinical investigative methods, may serve as an additional criterion to evaluate contractile function of the myocardium and for an individual approach to ordering physiotherapy using SHF electromagnetic waves for therapeutic purposes.

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